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Redescription of the tadpole of *Phlyctimantis boulengeri* Perret, 1986 (Anura, Hyperoliidae) with preliminary comments on the biology of the species

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We redescribe the tadpole of *Phlyctimantis boulengeri* Perret, 1986 based on specimens from Taï National Park, Ivory Coast. The tadpoles resemble very much those of the genus *Kassina*. We found no hints for arboreal spawning, as described by GUIBÉ & LAMOTTE (1958) for this species. Eggs were laid singly below the surface of water. Adults showed a conspicuous defence behaviour.

INTRODUCTION

In 1986, PERRET separated the West African and Cameroon specimens of *Phlyctimantis leonardi* (Boulenger, 1906) from those of Gabon describing the western forms as *Phlyctimantis boulengeri*. According to SCHIOTZ (1999), two distinct forms of *P. boulengeri* exist. The eastern one occurs in Cameroon and eastern Nigeria, the western one is in Ivory Coast and Liberia. Our specimens from Taï National Park, Ivory Coast, fit SCHIOTZ's description of the western form. In 1958, GUIBÉ & LAMOTTE published a description of a tadpole which they named *Hylambates leonardi*. While their adult voucher specimens are *P. boulengeri*, the tadpole they described was *Chiromantis rufescens* (Gunther, 1868) (LAMOTTE & PERRET, 1963, SCHIOTZ, 1975). LAMOTTE & PERRET (1963) noted that the tadpole descriptions of *C. rufescens* and *P. boulengeri* given by GUIBÉ & LAMOTTE (1958) were simply reversed (this was already clarified in the errata added to the latter paper). This view was accepted by SCHIOTZ (1975), DRIVER (1984) and ALTIG & MCDIARMID (1999). GUIBÉ & LAMOTTE (1958) described arboreal spawning in both species, although this is clearly not the case in *P. boulengeri*. Their drawings figure a tadpole that still possesses external gills and the oral disc of a certainly much older specimen. An identification of *P. boulengeri* tadpoles seems impossible with their description, even if it was based on that species. We present a description based on older tadpoles of known parents.

MATERIALS AND METHODS

STUDY AREA

Our study area was in the Taï National Park (6°10'-5°10'N, 7°20'-6°50'W), Ivory Coast. This is the largest protected rain forest area in West Africa. Annual precipitation reaches 2,200 mm in the south-west and 1,700 in the northeast of the park. Precipitation is highest from April-May to June-July and from September to October-November. A first dry period lasts from December to February. A second dry period normally occurs in August. Temperatures vary between 20 and 33°C, daily temperature differences are up to 10°C. Mean annual temperature is about 25°C. Humidity fluctuates from 85 % during day to 90-100 % during night. This area is situated within the equatorial climate zone which is influenced by the southern passat (RIEZEBOS et al., 1994). Floristically it belongs to the Guinea-Congo Region (GUILLAUMET, 1967). Our main investigation area was located about 23 km southeast of the small town of Taï and comprises an area of about 30 km^2 around the SRET station (Station de Recherche en Ecologie Tropicale; 05°50.003'N, 007°20.536'W). Precipitation at the SRET was 1,820 mm in 1999. Field data were collected from January to May and August to December in 1999 and March to October 2000.

REARING

In 1999, we got fertilised eggs from an amplectant pair of *Phlyctimantis boulengeri* (SMNS 9271.1-2). All tadpoles were reared in plastic aquaria (PT2 Firma Hoch, 25 × 15 cm, 16 cm water depth), filled with rain water and fed ad libitum with commercial fish food (TetraMin®). Water was changed every second to third day. In 1999 the tadpoles had not reached metamorphosis before our field season was finished. Therefore the most advanced tadpole of that series had only reached stage 32 after GOSNER (1960). In 2000 we collected tadpoles of more advanced stages but unknown age in two rock-pools on an inselberg, surrounded by primary rain forest.

PRESERVATION AND DESCRIPTIVE METHODS

Tadpoles of various developmental stages were preserved in 4 % formaldehyde. As, according to our experience, developmental time of West African tadpoles, even under best rearing conditions, is always slower in captivity than in the field (RÖDEL, 1998), we do not give developmental time tables. We only preserved tadpoles that already swam. All collected specimens, including the tadpoles' parents, are deposited in the collection of the Staatliches Museum fur Naturkunde Stuttgart (SMNS). In total we preserved 18 specimens (stage 25-42, SMNS 9271.3-20). Staging is according to GOSNER (1960). Nomenclature of morphological features is combined after VAN DIJK (1966), ALTIG & JOHNSTON (1989) and ALTIG & MCDIARMID (1999). The keratodont formula is after DUBOIS (1995). Measurements were

taken with dial callipers (± 0.5 mm) or with a measuring ocular at a dissecting (± 0.1 mm, Zeiss® Stemi SV 6) or compound microscope (± 0 01 mm, Leitz® Laborlux S), respectively. Drawings were done with the aid of a camera lucida. We noted coloration of several dozen live *P. boulengeri* tadpoles and then released them in their natural ponds. The tadpole description is mainly based on specimens of the Gosner stages 27-28 (tab. 1). Data are given for all preserved tadpoles.

Results

Tadpole description

Compact body, oval but compressed viewed dorsally (fig. 1a-b), body length 1.5 (1.2-1.9) times body width (measured at the plane of eyes); tail about two times (1.7-2 5) as long as body, more or less straight, if extrapolated, the axis of the tail passes dorsal to the eyes; tail with high fins, fin height 1.1 times body height, highest point of dorsal fin at the same level as highest point in ventral fin, dorsal fin originating anterior to dorsal tail-body junction, dorsal and ventral fin evenly curved along the first 2/3 of tail length, then evenly converging; small oral disc anteroventral (fig 2a), bordered by a multiple row of papillae that has a rostral gap, additional papillae groups occurring in the oral angles; jaw sheaths very powerful and black; upper jaw sheath uniformly U-shaped; lower jaw sheath deeper than wide, V-shaped, edges of both jaw sheaths slightly serrated, labial tooth row formula 1/2+2.1, supra-angular labial teeth positioned on a bulging lip, infra-angular labial teeth positioned on separate skin folds; third infra-angular tooth row always very short, labial teeth multidenticulate, four times as long as wide (fig 2b); nostrils dorsal (in stages 25-28 hardly visible), internasal distance as long as distance eye-nostril, distance nostril-snout tip 0 7 times the distance nostril-eye; eyes lateral; spiracle sinistral, visible from dorsal; vent opening medially in basicaudal position. In the two tadpoles of stage 40 and 41, a narrow groove stretches from the nostrils to the eyes. Measurements and ratios of the preserved tadpoles are summarised in tab. 1 Two especially large, uncollected tadpoles measured respectively 63 mm TL (stage 36), and 21 mm BL and 52 mm TL (stage 43) Older stages developed an increasingly elongated body (stage to BL/BW: Spearman rank, $r_s = 0.459$, $P = 0\ 055$, $n = 18$, for abbreviations see tab. 1). Larger tadpoles had comparatively higher fins (TL to FH, $r_s = 0.982$, $P < 0.001$, $n = 18$), but comparatively more flattened bodies (stage to BL/FH, $r_s = 0\ 946$, $P < 0\ 001$, $n = 18$) The anterior region of the caudal muscles in stages more advanced than 26 was obscured by connective tissue giving the appearance of a more muscular tail The basic colour of all investigated tadpoles is dark grey to black (fig 1a-b). The fin is always transparent. The ventral parts of body and tail are slightly clearer coloured than the dorsal ones, or mottled black

Biology

We never detected any *P boulengeri* even during rainy weather – from January to May. In 1999, we found choruses on two ponds from September to the beginning of October In

Table 1 Measurements (mm) and ratios of 18 *Phlyctimantis boulengeri* tadpoles (SMNS 9271 3-20) Staging after GOSNER (1960) BL, body length, AL, tail axis length, TL, total length, BW, body width, BH, body height, FH, fin height (including dorsal and ventral part of fin and muscular portion of tail); KF, keratodont formula (after DUBOIS, 1995)

Stage	BL	AL	TL	BW	BH	FH	BL/BW	AL/BL	BL/FH	TL/FH	KF
25	5.2	9.5	14.7	3.7	3.9	4.3	1.4	1.8	1.2	3.4	1/2+2:1
25	5.4	10.2	15.6	3.9	4.3	4.8	1.4	1.9	1.1	3.3	1/2+2.1
25	5.3	9.9	15.2	3.8	4.1	4.6	1.4	1.9	1.2	3.3	1/2+2:1
25	5.1	9.6	14.7	3.8	4.0	4.3	1.3	1.9	1.2	3.4	1/2+2:1
25	4.9	10.0	14.9	3.6	3.6	4.2	1.4	2.0	1.2	3.5	1/2+2:1
25	7.4	15.1	22.5	5.1	5.2	5.5	1.5	2.0	1.3	4.1	1/2+2:1
26	9.0	21.2	30.2	7.4	7.5	7.3	1.2	2.4	1.2	4.1	1/2+2:1
26	9.2	19.5	28.7	6.1	5.9	6.5	1.5	2.1	1.4	4.4	1/2+2:1
26	8.6	17.8	26.4	6.0	6.5	7.0	1.4	2.1	1.2	3.8	1/2+2:1
27	10.6	21.5	32.1	7.5	7.8	7.4	1.4	2.0	1.4	4.3	1/2+2:1
27	10.6	21.5	32.1	6.9	7.5	7.1	1.5	2.0	1.5	4.5	1/2+2:1
27	10.8	18.1	28.9	6.6	6.8	6.9	1.6	1.7	1.6	4.2	1/2+2:1
28	10.6	22.2	32.8	7.3	7.3	8.0	1.5	2.1	1.3	4.1	1/2+2:1
31	11.5	24.4	35.9	7.6	8.1	8.4	1.5	2.1	1.4	4.3	1/2+2:1
31	14.2	24.6	38.8	7.4	8.1	8.7	1.9	1.7	1.6	4.5	1/2+2:1
32	14.5	27.5	43.0	7.7	8.0	8.5	1.9	1.9	1.7	5.1	1/2+2.1
40	17.0	43.0	60.0	13.0	14.0	15.0	1.3	2.5	1.1	4.0	1/2+2.1
42	18.0	41.0	59.0	12.0	12.0	11.5	1.5	2.3	1.6	5.1	1/2+2:1

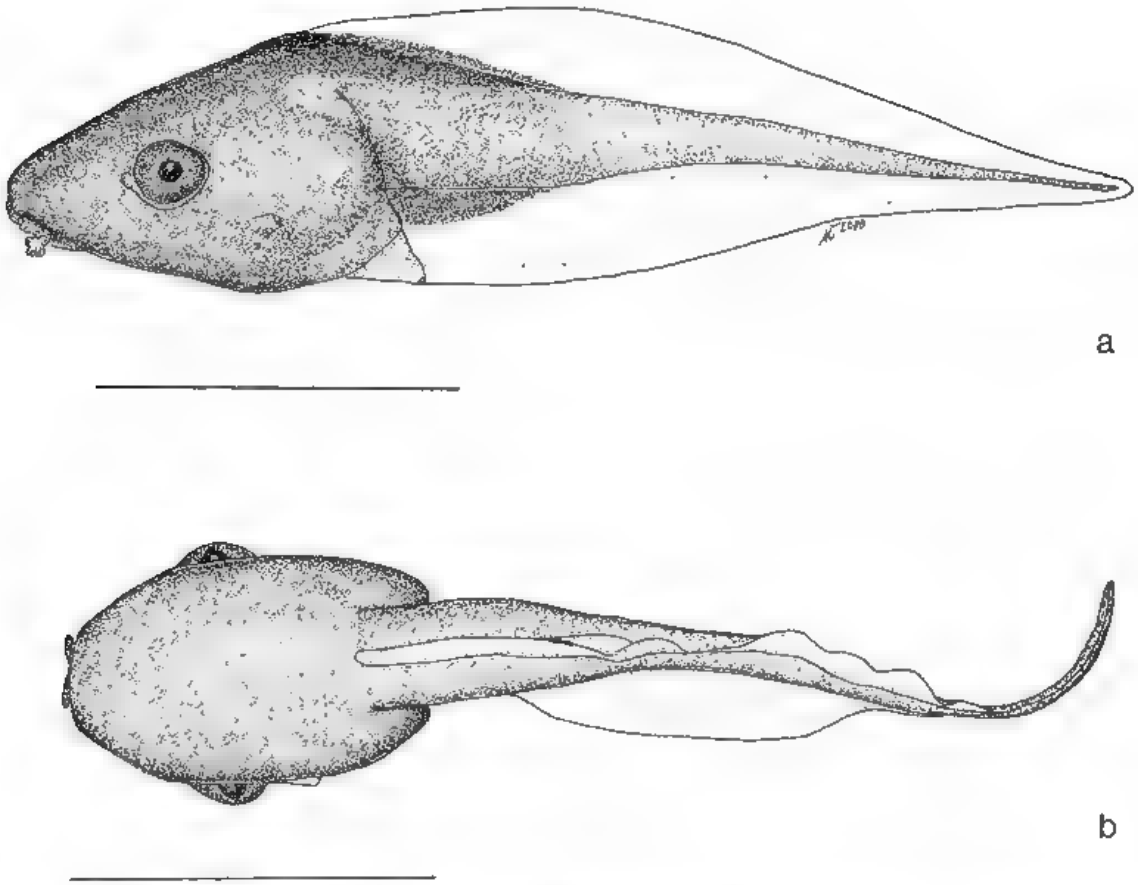

Fig 1 – Lateral (a) and dorsal (b) view of a *Phlyctimantis boulengeri* tadpole from Tai National Park, Ivory Coast (Gosner stage 28). Scale bar: 10 mm.

2000, we found the first chorus on June 2, after heavy rainfalls. The choruses comprised 5-20 males, all sitting in small trees and bushes at the edge of temporary ponds. Two ponds were situated in the forest, along an old logging road (pond diameter 15-30 m, maximal water depth 40-100 cm). Two other ponds were situated on a rocky inselberg (pond diameter 2 m, maximal water depth 20 cm). When disturbed, all adult *P. boulengeri* showed a conspicuous defence behaviour. They bent their back, hiding their head between the forelegs, and presented the red parts of the hind limbs (fig. 3). The animals secreted a sticky substance that covered their skin. On September 17, 1999, at 9.00 p.m., two hours after a heavy rainfall, we observed three amplectant pairs of *P. boulengeri*. The pairs were floating close to the edges of a large pond that had filled during the preceding days (fig. 4). When the frogs were disturbed they retreated to deeper sections of the pond, and re-appeared a few minutes later. We caught one pair (SVL: male 42 mm, female 52 mm) and transferred it to a plastic aquarium where they spawned the same night. The eggs were attached singly to the aquarium walls below the water surface. The clutch comprised 185 eggs. The ovum size was 2-2.5 mm (3-3.5 mm including the jelly capsule, $n = 20$), they had a small black and a large yellow pole. The first tadpoles hatched on September 26. On November 25, we preserved the last five tadpoles of

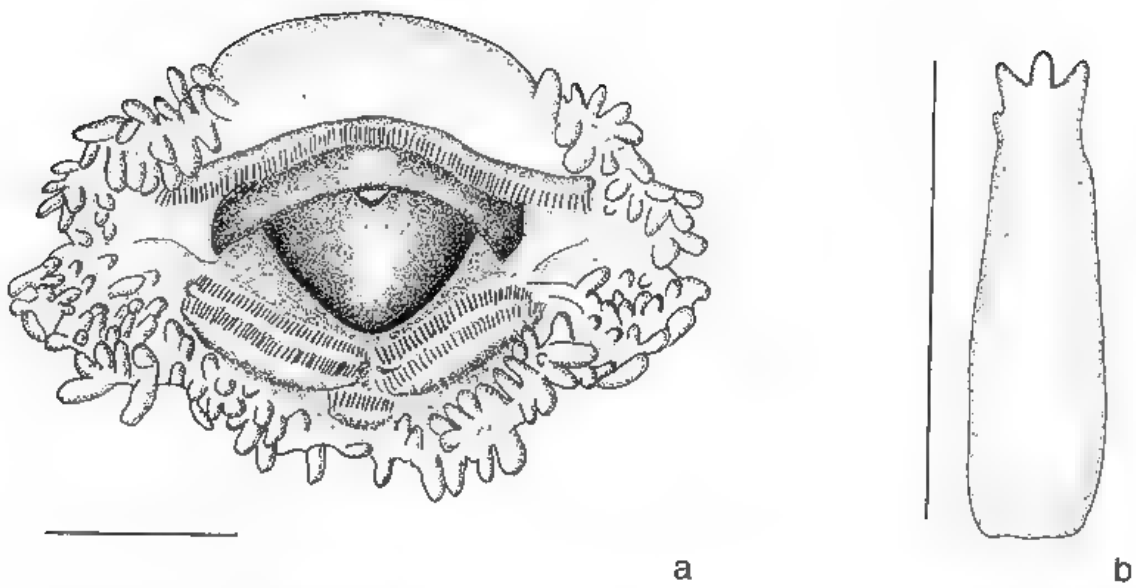

Fig 2 Oral disc (a) and single infra-angular labial tooth (b) of the specimen figured in fig 1 Scale bar a, 1 mm, b, 0 1 mm

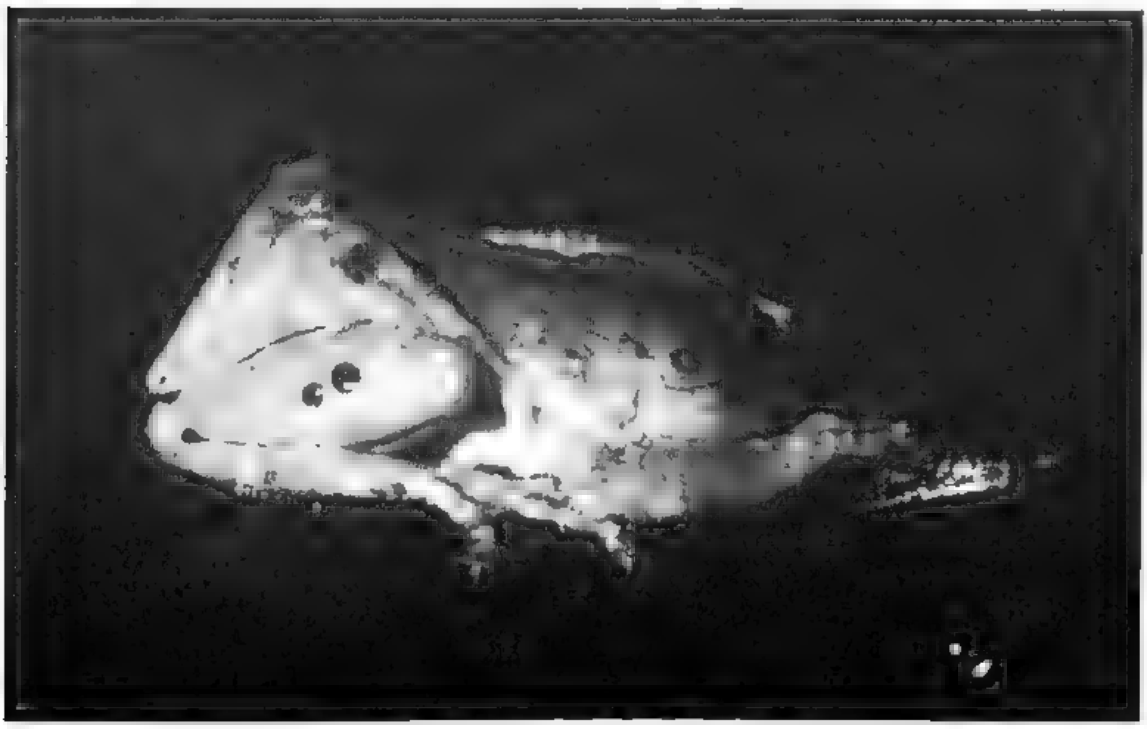

Fig 3. – Defence behaviour of an adult male *Phlyctimantis boulengeri*

Fig. 4 Amplectant *Phlyctimantis boulengeri* pair floating in shallow water of a large forest pond.

our 1999 series (stages 27-32). Three other clutches that we got from amplectant pairs (SVL: males 43-48 mm, females 51.5-54 mm) in June and September 2000 comprised 110, 210 and 339 eggs, respectively. Egg colour, egg size and time until hatching was equal to that of the first clutch. In the ponds, eggs were attached to the pond bottom or to rotten leaves.

Discussion

An identification of *Phlyctimantis boulengeri* tadpoles with the description given by Guibé & Lamotte (1958) under the name *C. rufescens* is not possible. These authors pictured a tadpole with external gills and an oral disc that clearly belongs to a much older specimen. The given keratodont formula fits nearly the formula of our tadpoles (they figured 1/1+1.2), but the fact that they reported *P. boulengeri* to deposit its eggs on leaves above the water surface leaves doubt concerning the correct identification of their specimens. According to our observation, *P. boulengeri* lays its eggs in the water. The same behaviour was described by Laurent (1976) for *Phlyctimantis verrucosus* (Boulenger, 1912).

Schiøtz (1975) described the tadpole of *P. verrucosus*. According to his description the tadpoles resemble our *P. boulengeri*. He indicated the keratodont formula of his two specimens as being 1/3 and 1/2+2.1. The fin of these tadpoles is rather high, but not as high as in

Kassina Girard, 1853. ALTIG & MCDIARMID (1999) characterised the species as exotroph, lentic and benthic. The body pattern is described as uniformly pale with blotches. Our tadpoles fit this ecological characterisation. They closely resemble the tadpoles of *Kassina fusca* Schiøtz, 1967 with transparent fins (RÖDEL, 2000). This might be a further hint for the supposed close relationship of *Kassina* with *Phlyctimantis* Laurent & Combaz, 1950 (DREWES, 1984). However, this could be also a plesiomorphic character. To clarify the phylogenetic relationship of *Kassina* and *Phlyctimantis* we propose a closer examination of their genetic and call characters.

SCHIØTZ (1999) wrote that all four currently recognised *Phlyctimantis* species require forest conditions at their breeding localities. According to SCHIØTZ (1975) and LAURENT (1976), in eastern Zaire and Uganda the breeding sites of *P. verrucosus* were small stagnant, probably temporary pools in very dense forests. Males of *P. boulengeri* called in vast numbers around small waterholes in forest and sometimes in bushland (SCHIØTZ, 1975). PERRET (1966) reported that *P. leonardi* occurs near rivers in forests of low altitude in Cameroon. Males of *P. leonardi* from the Republic of Congo called from elevated (1-2.5 m) positions in large bushes at the edge of deep, but temporary ponds (LARGEN & DOWSETT-LEMAIRE, 1991). These males called from bushes in flooded grassland, but not from the nearby flooded forest. *Phlyctimantis keithae* Schiøtz, 1975 from Tanzania called around artificial ponds in very open farmland (SCHIØTZ, 1999). The males were concealed in grass-tufts near the water's edge and quietly slipped into the water if disturbed. All our *P. boulengeri* records lay within or in close vicinity to forest habitats. However, we never found that species within closed primary forest. The breeding sites were all in degenerated forest or in habitats without a closed canopy. We detected calling males of *P. boulengeri* exclusively in small trees and shrubs in close vicinity to their breeding ponds. It might therefore be concluded that *Phlyctimantis* species most often require forest habitats, but avoid closed primary forest.

Disturbed *P. boulengeri* displayed a conspicuous defence behaviour. During that behaviour their skin turned very sticky. DREWES & VINDUM (1994) reported a similar observation on *P. verrucosus*. Their specimens were covered with a latex-type liquid which had a rather noxious smell. The biological significance of this behaviour and the chemical nature of the secretions need further investigations.

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